High resolution seismic prospection of old gypsum mines - evaluation of detection possibilities

Bogdan Piwakowski, Jean-Marc Watelet, David Moreaux, Khalid Sbai

HIGH RESOLUTION SEISMIC PROSPECTION OF OLD GYPSUM MINES - EVALUATION OF DETECTION POSSIBILITIES

BOGDAN PIWAKOWSKI[1], JEAN-MARC WATELET[2], DAVID MOREAUX[1], KHALID SBAI[1].

[1] Laboratoire de Physique des Vibrations et d'Acoustique (IEMN DOAE UMR 9929CNRS) Ecole Centrale de Lille, 59651 Villeneuve d'Ascq, BP48, France.
[2]Institut National de l'Environnement Industriel et des Risques (INERIS) 60550 Verneuil-en-Halatte, France.

INTRODUCTION

The aim of this work is to evalute the location and detection possibilities of the old underground gypsum mines, appearing in the region of Paris, and being now unexploited, which represents a real danger both for population and building activities. The experiments* were conducted in the site affected recently by serious accidents, caused by ground collapses. They included the application of the high resolution seismic reflection, microgravimetry** and resistivity** methods. The results obtained were tested by the drilling. The positions of the researched galleries were generally unknown and their occurence was only suspected due to the presence ground-collapse (GC) areas caused by the natural collapse of a cavity. Some of the GCs were observed directly at the surface, the others were detected by means of the comparison of the old and recent aerial photographs. Figure 1.a. shows the general geological data of this site and the locations of the seismic profiles S2,S3,S4 considered in this report.

The seismic data was recorded using the 100 Hz geophones and the silenced "betsy gun" as a source (designed in laboratory). The closest offset had been individually adapted, based on the approach of the optimum offset window.

RESULTS

The seismic section of the profile S3 (Fig.1.c) reveals the expected layers AG, G, M (and S in some locations). Two zones of the strong discontinuities of this structure, observed in the intervals CDP (30-50) and CDP (200-320), well correlate with the positions of the ground collapses GC1, GC2 and GC3 (Fig.1.b) and with the gravimetric anomalies (Fig.1.d). The resistivity measurements, having given no consistent results for this profile, are not presented.

The several smaller anomalies occuring within the interval CDP(100-200) are detected by the seismic, which, in fact, seems to be more precise and more sensible. Two of them (CDP 135 and CDP 195) tested by the drilling (SD3 and SD6, Fig.1.b), reveal no artifical void apart from the relatively important natural karstic type anomalies in the MG layer.

The seismic profile S4 (Fig.2 a.) shows the clearly identified strong discontinuity between CDP 295 and CDP 330. In fact, this anomaly respresents probably an old gallery, partially

* The experiments were financed by Ministry of Environment et managed by INERIS
**Conducted and interpreted by Sociéte CPGF HORIZONS, 12 rue de Paris, 78230 - Le Pesq

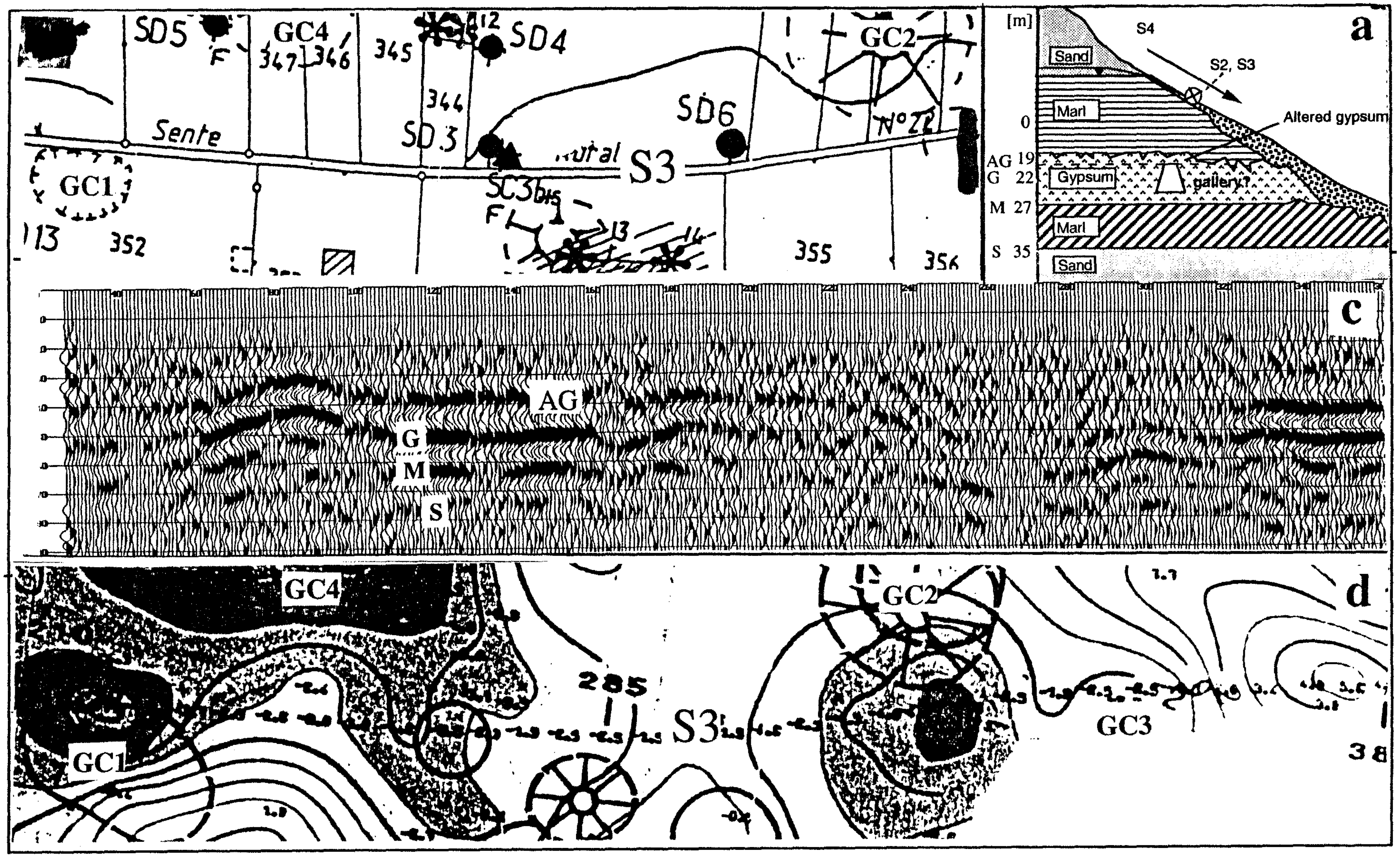

Fig.1: (a) General geological data in the region of experiments. S2,S3 and S4 indicate the locations of the seismic profiles; (b) location of the profile S3, in regard with the positions of ground collapses GC1, GC2,GC3 and GC4. (c) Seismic section for the profile S3; (d) Anomalies gravimetriques for the area along profile S3

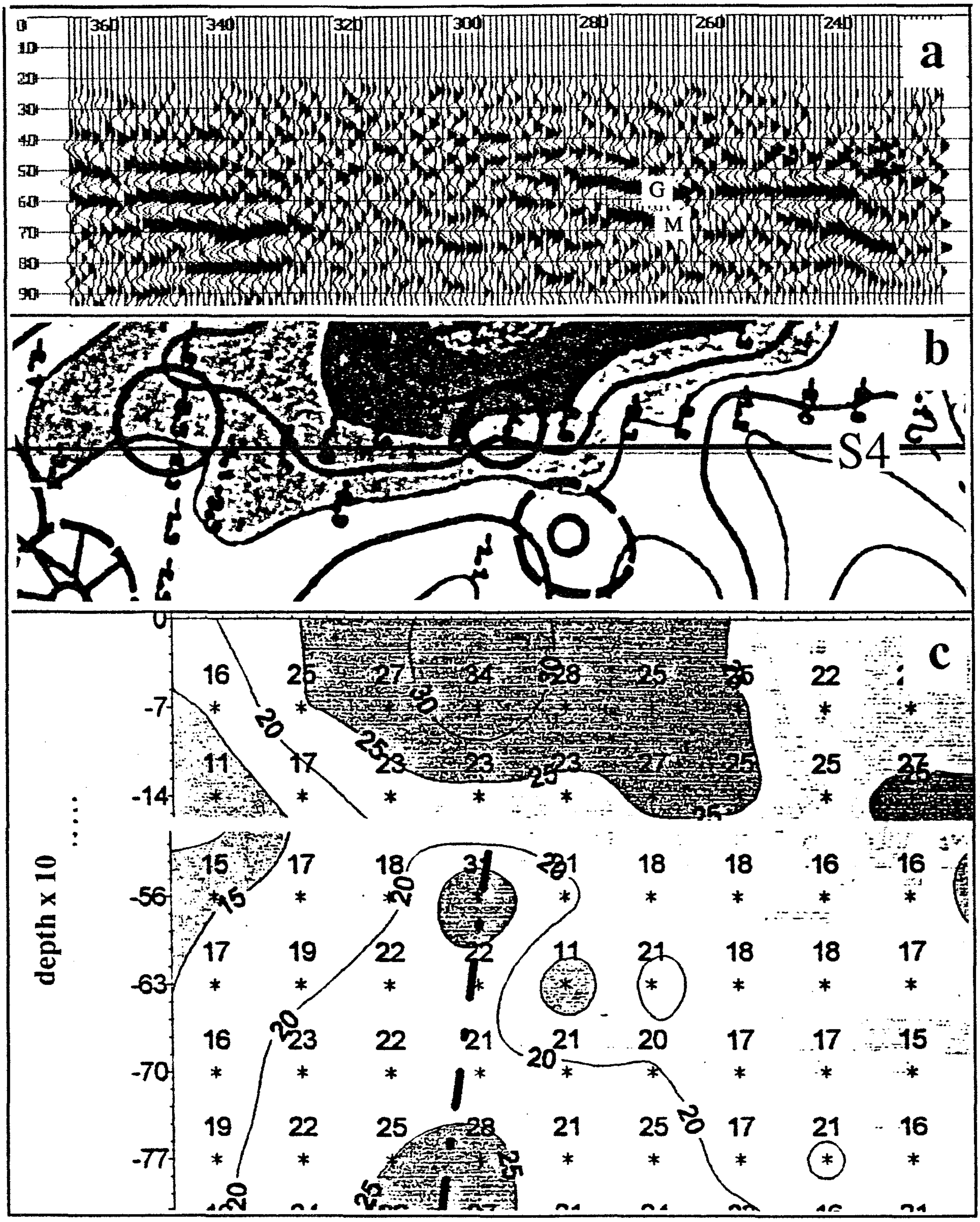

Fig.2: **(a)** Seismic section of the profile S4; **(b)** Anomalies gravimetriques for the area along the profile S4 **(c)** Anomalies of the resistivity for the profile S4

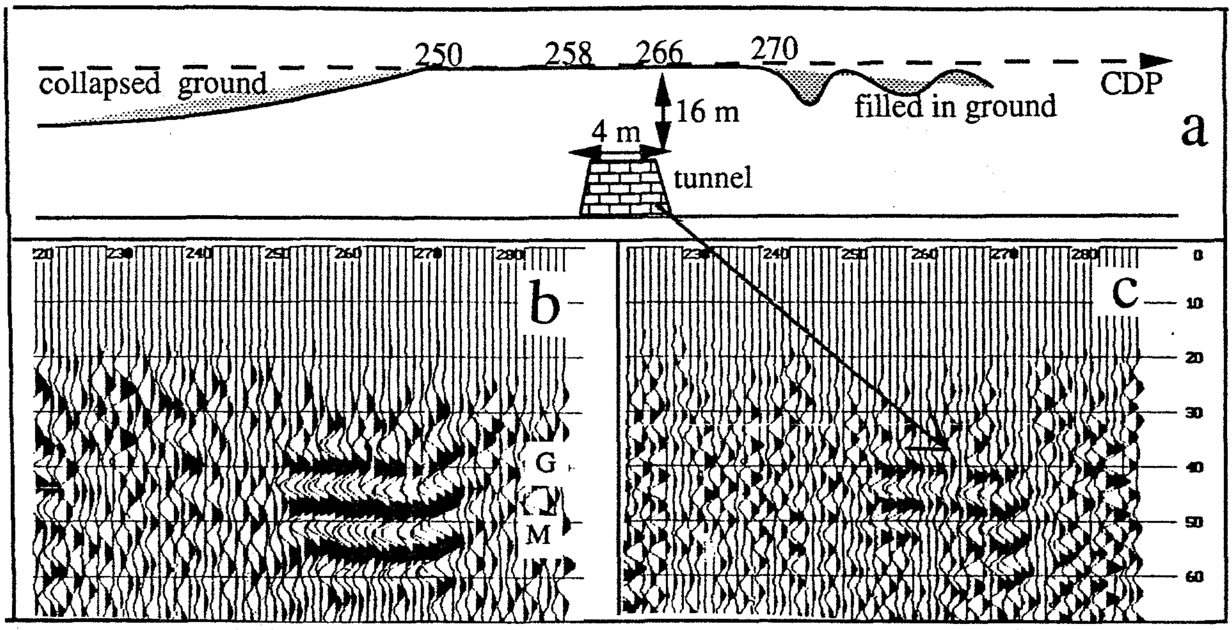

Fig.3: **(a)** Position of the profile S2 in regard with the location of the tunnel and of the collapsed zone; **(b)** obtained seismic section for $D/\lambda=0.65$ and $S_c/S_f=0.3$; **(c)** Same as (b) except for $D/\lambda=0.9$ and $S_c/S_f=0.43$

collapsed (GC4,Fig1.b) and characterised by a "lifting void" located by drilling at the depth of 11 m. A similar image of the cavity, located beyond the first geological marker, can also be also found in [1]. This detection is very well correlated both with gravimetric and resistivity results (Fig.2.b,c).

The seismic section S2 was conducted along the profile (Fig.3.a) including one single tunnel of width D=4 m, the collapsed zone and un unloaded zone. The seismic image (Fig.3.b) reveals the "normal" geological structure within the zone CDP (250-273). The luck of signal respectively in the areas CDP<250 and CDP>274, is interpreted as the occurence of the expected collapsed and filled-in ground

Concerning the detection of tunnel, we point out the basic principle of the imaging which states that the detection of an object of dimension D depends on the D/λ ratio. For the seismic imaging the possibility of detection may be expressed as a function of the the Sc/S_f ratio, where S_f is the surface of the Fresnel zone [2] and S_c is the object surface included in S_f. The comparison of sections (b) and (c) of Figure 3 shows that the tunnel is detected (precisely between the CSPs 258 and 266) only at the section (c) being processed at sufficiently high frequency (Sc/S_f ratio closer to 1). The gravimetric method did not give any consistent results in this case.

CONCLUSIONS

1. The high resolution seismic is quite efficient for the location of the collapsed zones and at the same time it seems to be the most precise and sensible among the compared methods.
2. The seismic detection of the single and isolated tunnel of dimensions smaller and compared to the Fresnel zone, seems to be quite impossible in the real field conditions.
3. The gravimetry seems to be less sensible than seismics which detects even karstic anomalies. However, for the greater anomalies, its results correlate wery well with seismic.
4. The resistivity is more sensible for the diffrent perturbations and remains therefore less efficient. Under good conditions, it give results well correlated with other methods.

REFERENCES

[1] B.PIWAKOWSKI, Rapport sur l'avancement de la recherche dans le cadre de GEO Thème: Cavité dans la zone urbaine Sujet: Localisation des galeries souterraines .EC-Lille, IEMN OAE LPVA, 1995

[2] B.PIWAKOWSKI, J.C.TRICOT and B.DELANNOY:" Underground tunnels detection and location by high resolution seismic reflection" Proceedings of 56 th International Symposium of European Association of Exploration Geophysicists , Vienna, June 6-10,1994.